American Mineralogist, Volume 68, pages 655–656, 1983

Acceptance of the Mineralogical Society of America Award for 1982

ROBERT M. HAZEN

Geophysical Laboratory
Carnegie Institution of Washington
Washington, D. C. 20008

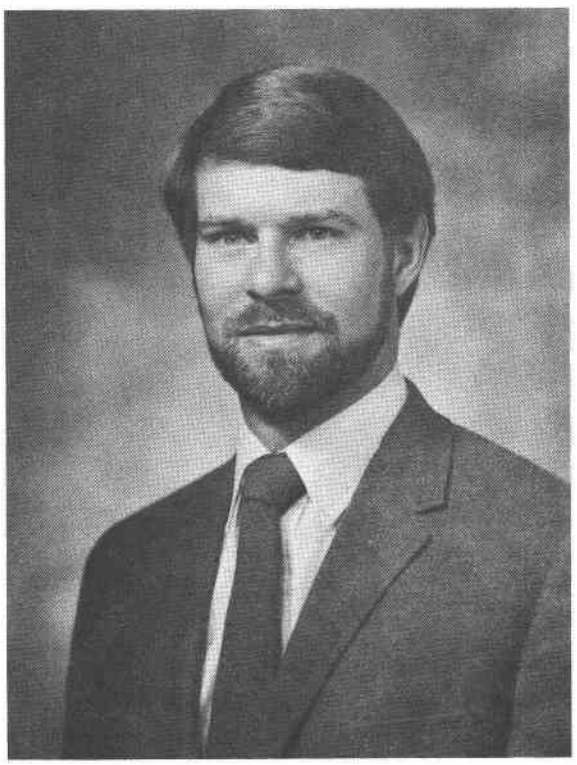
President Lindsley, Charlie, Friends and Colleagues:

You have given me a great honor, and an even greater privilege. I am honored to be so recognized by my good friends and colleagues of the MSA. We all know, however, that for a young scientist such an award speaks as strongly for those who taught and guided, those who set an example too persuasive and eloquent to be missed by the novice. My great privilege, therefore, is this opportunity to thank publicly a few of the many who laid such a well-marked path to this podium.

My career in mineralogy was first inspired by Bill Welsh, my junior high school science teacher in Ridgewood, New Jersey. Bill spent hours with me outside the classroom, and quickly turned my inveterate collecting instincts from bottle caps and baseball cards, to the challenges of mineralogy.

My parents were no less an influence—they gave up many weekends for excursions to the quarries of Patterson and the dumps of Franklin. I have vivid memories of late-night trips home from Franklin with our headlights blinding all oncoming drivers, because the trunk of our '55 Buick was invariably weighted down with new treasures for a fluorescent rock garden.

I arrived at MIT in the Fall of 1966 with a desire to learn more about geology and mineralogy. My enthusiasm was more than matched by Dave Wones, also just arrived in Cambridge. In my five subsequent years studying with Dave, his exuberant spirits, demanding standards, and paternal concern for students became an example and guide for those lucky enough to work under him. In addition to factual details of mineralogy and petrology, which Dave stressed as essential to any geological education, he also emphasized the necessity of placing facts into a larger framework of the earth sciences. Our class field trips, long affairs, often through rain and sleet with only the briefest hiatus to take note of a blue heron or pileated woodpecker, were marvelous and stimulating experiences. In the best tradition of the United States Geological Survey, Dave was neither pedantic nor dogmatic—he practiced the philosophy of multiple working hypotheses, and encouraged the lively debates that always resulted. This lesson in philosophy has been of recurrent value to me. I should add that at a time when some professors called on me to abandon music as a frivolity, Dave steadfastly supported my efforts. For this, too, he has my deepest gratitude.



It was also during those MIT years that Margaret and I were married. It is said, both of scientists and musicians, that we are not always easy to live with. Yet, as professional colleague, mother of our two children, and my very best friend, Margee has always supported and strengthened me. Surely my path would have been far more difficult without her.

At MIT I had studied phase equilibrium, and Dave Wones firmly planted the idea that stability and crystal structure were closely related. So my move upstream to Charlie Burnham's crystallographic lab, in retrospect, seems to have been inevitable. If we are to understand mineral stability from a structural basis, then it is obvious that structural variations with temperature and pressure must be measured. Joe Smyth, fresh from his doctoral work at Chicago, had already solved half of that problem, and he proved a patient and skilled teacher in high-temperature crystallography. By a marvelous coinci-

0003–004X/83/0506–0655$02.00

dence, Bill Bassett was visiting MIT while I was at Harvard, and he introduced me to the miniature diamond cell for single crystal studies. No one had used the cell on a four-circle diffractometer, but in my naïveté I barged ahead with a high-pressure structure refinement. It worked (well, sort of) and my thesis topic was obvious.

During this period Charlie Burnham was an inspirational teacher and supportive guide in research. He was always ready to help and advise when asked, but he also encouraged his students to develop ideas and experiments independently. In fact, Charlie often said, only half in jest, that the best thing he could do for his students was to go on sabbatical. Of course we all relied on him, but I believe that the recent success of several of Charlie's graduate students has been due in large part to this belief in the importance of self-reliance.

My years at Harvard were also enriched by many friends, particularly Tim Grove, who generously shared his ideas, his enthusiasm, and his chicken soup.

In the mid 1970's, when I first became interested in mineral structures at nonambient conditions, a great deal of data were being collected, but there seemed to be no models for how structures should change with temperature or pressure. We simply ran experiments to see what happened. As a NATO Fellow in Cambridge, England, I had the good fortune to work with Charlie Prewitt, who was also a visiting researcher. When we weren't enjoying the twice-daily tea or local pubs, we resolved to look for ways to predict variations of bond distance with temperature and pressure, so we would at least have a model of behavior to test. I was much impressed with the simplicity and predictive power of Pauling's Rules, so we tried to relate bond expansion and compression to the basic ionic bonding parameters—bond distance, coordination number, and cation and anion formal charge.

What we found was remarkably simple. Bond expansion is inversely proportional to Pauling bond strength, and bond compression is proportional to polyhedral volume. A logical consequence of these empirical trends is that temperature, pressure, and composition are often analogous in the ways they modify structure. For example, structural changes during compression are often similar to changes during cooling. So in 1976 we had a set of working hypotheses to model structure variations with temperature and pressure.

The philosopher Alfred North Whitehead once said that the role of the naturalist is to seek simplicity in nature, and then to distrust it. Far from proving pet theories, my next research objective was to test these obviously over-simplified models of mineral behavior. I might well have failed in that task, and certainly would not be here today, were it not for the opportunities given to me by Hat Yoder to work at the Geophysical Laboratory. Long known for work at high temperatures and pressures, the Lab is especially fortunate now to have Peter Bell and Dave Mao leading the diamond cell research program. They have been more than generous with advice and assistance. A steady stream of guest investigators, in particular our predoctoral fellows Russell Ralph, Linda Pinckney, John Hughes, and Joseph Mariathasan, have greatly enriched life at the Lab.

But my greatest good fortune as a research scientist has been the privilege to collaborate with Larry Finger, whose expertise in experimental methodology, computer software, and instrumental design is second to none. In particular, Larry's grasp of the physics of diffraction has led to success where I alone would have failed. Our collaboration has been stimulating, productive, and a continuous source of enjoyment for me. All of you who know us realize that this year's MSA Award is a joint recognition.

Larry and I tested the model of structure variations. Although many common minerals, including framework, layer and chain silicates, fit the model quite well, other compounds failed dramatically. Garnet and rutile are two examples which deviated from predicted behavior.

It is perhaps time now for another, more rigorous, model of structure variations with temperature and pressure. We need to consider electronic structure of cations and anions, variations of bond angles, and a more elaborate form of bond strength. Other exciting directions for mineralogical research include the structural mechanisms of phase transitions, relationships between structure and thermochemical properties, and structural controls of diffusion-related processes. Your recognition today is a generous and valued incentive to continue this research.